Date 4/6/78   Time 800-1500   Experimenters F. Pedersen, E. Raka, E. Gill

Subject Longitudinal Impedance Measurements II

OBSERVATIONS AND CONCLUSION

Introduction:

As in the previous run the goal was to drive some of the potentially unstable
coupled bunch resonant modes in the neighborhood of h = 12. Exciting both dipole
and quadrupole oscillations and measuring accurately their frequencies along with
a determination of the unperturbed bunch length will then permit a calculation of
the imaginary part of the coupling impedance at a given energy.

Procedure:

The intensity was reduced to $\sim$ 2.5 x 10^{12} and transition adjusted for no phase
space dilution. Then a 1 sec. flat top was added to the magnet cycle and fast ex-
traction set up at the end of this time. Next the frequency synchronization loop
was closed on the flat top and it functioned perfectly. That is the beam frequency
was synchronized to a stable external oscillator at 4,454,861 C.P.S. in a phase
lock loop. Then a small amount of rf excitation was added to the 9 accelerating
stations at the 13th and 14th harmonics ± the phase oscillation frequency and twice
the phase oscillation frequency ($\sim$ 180, 360 C.P.S.). The E-20 WBPU was fed to the
HP spectrum analyser which was tunned to $\sim$ the exciting frequency with bandwidths
30-300 cycles (no sweep). One then looked for a growing amplitude of one of these
lines during the .2-.3 second period of the rf excitation. Fine tunning of the
excitation frequency in step of 1 or 2 cycles/sec. permitted accurate determination
of the resonant frequency of a given mode.

Observations:

Considerable time was lost adjusting the radial control loop to carry the beam
through the flat top and to set up the fast extracted beam, so data was taken only
during the last 90 minutes of the run.

Excitation of the dipole mode at the upper and lower sideband of the 13th har-
monic yielded a clean reproducible linear growth of the resonances. The upper side-
band or n = 1 coupled bunch mode exhibited a slow exponential additional growth after
the excitation was removed while the lower sideband or n = 11 mode decayed in the
expected manner when the excitation was removed.

Similar growth was observed when the quadrupole mode was driven at h = 13 but
both signal decayed after the excitation was removed. This is not understood since
it was expected that the quadrupole mode for the upper sideband would also be unsta-
ble. Finally the dipole mode sidebands at h = 14 were driven but this time the rate

of growth during excitation was not linear. A fast initial rise was followed by
a rapid decrease in slope which continued to decay with time. After removal of
the excitation the upper sideband actually exhibited a slight decay while the lower
sideband showed a slight growth. This again is a result that needs further investi-
gation.

Results:

In any event a very accurate measurement of the coherent dipole frequency was
obtained; $178.5 \pm .5$ C.P.S., from both $h = 13$ and 14 excitation. The quadrupole
frequency from the $h = 13$ excitation was $3511.6 \pm .7$ so that Δf the incoherent dipole
frequency shift is $2 \left| f_q - 2f_d \right|$ or 10.8 C.P.S. This along with the $\overset{\sim}{} $ bunch length
of 19 nsec and a $V_{rf} = 262$ Kv as determined from the beam energy and f_d results in
a $Z/n \overset{\sim}{} 36 \ \Omega$ inductive at 27.4 GeV.